Platinum-Group-Metal High-Entropy-Alloy Nanoparticles

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The platinum group metals (PGMs) are six neighboring elements, i.e., ruthenium (Ru), rhodium (Rh), palladium (Pd), osmium (Os), iridium (Ir) and platinum (Pt), in the periodic table of the elements, which are crucial to our daily lives, from household items to industrial catalysis. One in four of the goods manufactured today either contain PGMs or are produced through processes promoted by PGM catalysts.[1] Each PGM can efficiently promote unique reactions, and therefore, alloying PGMs would create ideal catalysts for complex or multi-step reactions that involve several reactants and intermediates.

High-entropy alloys (HEAs), which are defined as at least five elements in near-equiatomic concentrations (recently reported as 5–35 at.% for each constituent),[2] boost the discovery of new materials and phenomena, especially in structural bulk materials. However, the development of HEA nanoparticles (NPs) is limited by the synthetic method, which mainly require special experimental apparatuses.[3] Here, we report the first example of HEA NPs of all six PGMs (denoted as **PGM-HEA** NPs) using a facile wet chemical synthesis (**Figure A**) and demonstrate that PGM-HEA NPs efficiently promote the ethanol oxidation reaction (EOR) with complex 12-electron/proton transfer processes. **PGM-HEA** NPs shows higher activity than the commercial catalysts. Remarkably, **PGM-HEA** NPs record more than 1.5 times higher mass activity than the most active catalyst to date. The valence band spectrum of HEA NPs is featureless, which suggests a great variety of adsorption sites on their surfaces. Our findings pave the way for promoting complex or multi-step reactions that are seldom realized by mono- or bi-metallic catalysts.

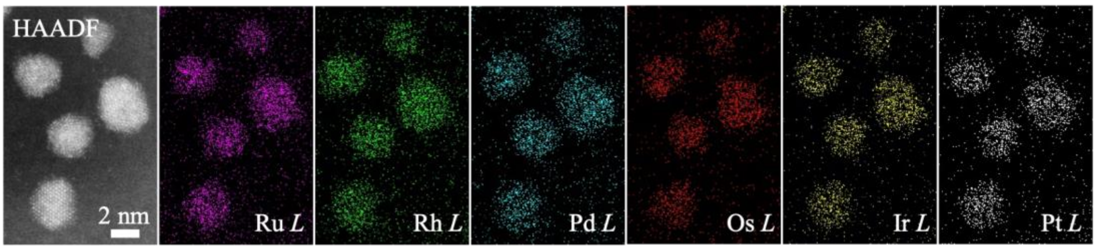

Figure A. HAADF-STEM image of the **PGM-HEA** NPs and the corresponding EDX maps using the *L*-line characteristic X-ray from each element.

1) Thermofisher homepage. https://www.thermofisher.com/blog/metals/platinum-group-metals-at-work-industrial-applications/. 2) a) J. Yeh et al., *Metall. Mater. Trans. A*, **2004**, ***35***, 2533. b) E. George et al., *Nat. Rev. Mater.*, **2019**, *4*, 515. 3) Y. Yao et al., *Science* **2018***, 359*, 1489.